REMARKS/ARGUMENTS

Description of amendments

Claims 1, 2, 4-10, 13, and 15 are now pending and under examination. Applicant has amended claim 9 and cancelled claim 14. No new matter has been added.

Allowed and allowable claims

Applicant appreciates that the Examiner has allowed claim 10.

Rejection under 35 U.S.C. §112, second paragraph

Claim 14 was rejected under 35 U.S.C. §112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicant regards as the invention. Cancellation of claim 14 renders the rejection moot.

Rejections under 35 U.S.C. §103(a)

Claims 1-9 and 11-15 were rejected under 35 U.S.C. §103(a) as being obvious on various grounds as set forth in paragraphs 4-14 of the Office Action. The rejection of cancelled clam 14 is now moot. For the following reasons, Applicants respectfully request reconsideration and withdrawal of the rejections of the other rejected claims.

Applicants respectfully submit that the cited references, Wallin and Takemura, do not disclose the presently claimed invention, and the obviousness rejections based on the combination of the those references are improper. Also, the references do not provide the motivation to solve the lubrication and raceway surface roughness problems dealt with by the presently claimed invention. Specifically, for the following reasons, Applicants respectfully submit that the obviousness rejections of claims 1, 2, 4-7, 13, and 15, which are based on Wallin and Takemura, are improper.

The claimed invention uses a lubricant containing one of a fluoro-polymer and a fluorides-containing gas. Lubricants, such as highly corrosion resistant and less evaporative fluoro-lubricating oil, are used for bearings operating in a reduced pressure atmosphere, such

as in a vacuum pump, and, particularly, under a high temperature (see the specification at page 2, lines 14 to 25). In addition, fluoro-lubricants, which are heat-resistant, less evaporative and chemically stable, are used under high temperature conditions often exceeding 200°C, such as in a heat roller for manufacturing the components of business machines (see the specification at page 3, lines 6-10).

A problem with a lubricant containing one of a fluoro-polymer and a fluorides-containing gas is that the lubricant has a high specific gravity and its wettability tends to deteriorate, making the formation of lubricant membranes (films) more difficult (see the specification at page 5, lines 18-23). Also, when these severe lubricating conditions are combined with insufficient lubrication, peeling wear or peeling flaking of the bearing's raceway surfaces may occur (see the specification at page 6, lines 2-6). Additionally, as set forth in the specification at page 6, line 25 to page 7, line 9, fluoro-lubricants react with iron to form iron fluorides, which function as a catalyst to make fluoro-lubricants decompose, resulting in the erosion of the surfaces of the rolling element, the bearing ring and cage (addressed by claim 8).

Furthermore, when oil membrane breakage or the like causes a high local temperature, the fluoro-lubricants react with Si as the main ingredient of silicon nitride, resulting in abnormal wear (see the specification at page 7, lines 14-19).

Still further, regarding the subject matter of claim 9, in bearings for use in a vacuum pump lubricated with fluoro-lubricants, since fluoro-lubricants have poor wettability, lubrication around the cage is reduced, resulting in surface roughness. The rolling element is then damaged and makes the surface roughness worse (see the specification at page 9, line 15 to page 10, line 11). The rough surfaces of the rolling elements result in peeling of the inner and outer rings' raceways.

The following discusses a method used by the claimed invention to solve the above-discussed problems and to prolong the life of a rolling bearing using fluoro-lubricants.

It has been shown that the rolling elements are worn with fluoro-lubricants when the roughness of the inner ring or outer ring is increased. As shown Fig. 2, when the roughness

of the inner ring or outer ring exceeds 0.05 μm Ra, bearing life is lowered significantly. This is the standard used in the claimed invention for limiting raceway surface roughness of the inner ring or outer ring (see the specification at page 14, lines 1-22).

Differences between the presently claimed invention and Takemura

The presently claimed invention and Takemura have a common object, that is, to reduce peeling damage to prolong the life of a rolling bearing.

In general, it has been recognized that to prolong the rolling fatigue life of a rolling bearing the value of an oil film parameter Λ must be increased, and the oil film thickness must be increased. The equation for the oil film parameter Λ and its meaning are described in Takemura (column 1, lines 10 to 33).

However, in Takemura, the bearing is placed in a "boundary lubrication state" with Λ=1.5, and the surface roughness (σ_2) of each rolling element and the surface roughness (σ_1) of the mating member are in the range of 0.15 to 0.5 μm Ra. The mating member of Takemura can be understood obviously to correspond to the inner and outer ring surface roughness of 0.05 μm or less, which is different from the presently claimed invention.

In Takemura, there are two factors in the determination of the critical mean of the surface roughness (column 3, lines 33 to 42). The manufacturing costs for grinding the surfaces of the rolling elements and mating member to ultra-high accuracy become substantially equal to the costs of a needle roller. The surface roughness is specified in a range which is obtained by subjecting the rolling elements and mating member to ordinary grinding and polishing (column 2, lines 7-15).

By contrast, the presently claimed invention is used in a state, in which the formation of lubricant membranes (films) is difficult, as described above.

Using the oil film parameter (Λ), the differences in motivation between the presently claimed invention and Takemura can be easily understood.

As described above, a higher oil film parameter Λ results in a longer bearing fatigue life. Higher oil film parameter Λ requires higher minimum oil film thickness and less square average roughness of contact surfaces (between the raceway surface of a bearing and rolling elements. To prolong the fatigue life of a bearing, the presently claimed invention and Takemura use different methods to increase parameter Λ.

The presently claimed invention has less square average roughness, because h_{min} is small. In Takemura, by contrast, since the boundary condition mentioned above is not inevitable, the square average roughness is larger and is selected with a higher h_{min} lubricant, as is the case with the disclosed turbine oil (column 3, line 61) which is a mineral oil, not a fluoro-lubricant.

To summarize, a difference between the presently claimed invention and Takemura is how the square average roughness h_{min} is selected to obtain a long bearing service life by preventing peeling damages.

Differences between the presently claimed invention and Wallin

Wallin discloses a useful application of bearings in high speed screw compressors having a pair of angular bearings, in particular a useful application in so called "dry air screw compressors." At column 2, lines 32-35, Wallin describes a bearing arrangement for eliminating ball sliding and shuttling to produce lower operating temperatures, stable oil viscosity, consistent film thickness and longer service life.

The presently claimed invention provides an improvement over the prior art, in particular, in the bearing systems disclosed in the MRC publication described in Wallin. For example, the PUMPAC Bearing System described in Wallin is designed for centrifugal pumps wherein the maximum speed is up to an ndm value of 550,000. Compressor assemblies of the present are designed for operation at 750,000 to 1,100,000 ndm.

As the Examiner pointed out in the Office Action, even if "the MRC PUMPAC Bearing System and its improvements for high speed" use oil for lubrication, it cannot change the fact that Wallin does not disclose not only the use of fluoro-lubricants but also the raceway surface roughness of the presently claimed invention.

In conclusion, Takemura and Wallin do not teach or suggest the lubrication and raceway surface roughness of the presently claimed invention. Therefore, the obviousness rejections are improper.

Rejection of claim 8 as unpatentable over Otsutake

It was incorrectly stated in the Office Action that "the size for the opening of a pocket" of claim 8 and "the cage pocket clearance" of Otsutake are equal or equivalent. In fact, they are very different, in particular, in terms of objects and functions.

Regarding the size for the opening of a pocket of claim 8, claim 8 is based on the seventh embodiment described in the specification from page 80, line 19 to page 89, line 5. In describing the cage of claim 8 at page 88, lines 6-17, the specification states that "the size A for the opening of the pocket 21 having the weld line 26 is set to a value large than 93% for the rolling diameter c... [and] the opening of each of other pockets 22 is set to a value of 80 to 93% for the rolling diameter" and that "[a]ccordingly, drop off of the cage 20 for use in the rolling bearing ...and occurrence of cracks or breakage at the bottom of the pocket 21 having the weld line 36 can be prevented reliably upon assembling...."

As mentioned above, an object of claim 8 is to prevent the occurrence of cracks or breakage at the bottom of the pocket having the weld line and the drop off of the cage, because the pocket having the weld has less strength than the rest of the pocket (see the specification from page 7, line 25 to page 8, line 22) and is made from an advanced resin material with excellent corrosion resistance, such as polyphenylene sulfide (PPS) resin and polybutylene terephtalate (PBT) resin (page 31, lines 5-9). The materials are also heat resistant when used with a fluoro-lubricant.

Regarding the cage pocket clearance, in paragraph [0003] of Otsutake, in the injection molded retainer, the gate part and weld part have a large molding shrinkage compared with the other part. Therefore, the cage pocket clearance between a rolling element and the pocket internal circumference in an outer-diameter surface may be reduced or eliminated. Also, in paragraph [0006], the molding shrinkage of a retainer is larger near the gate part and near the weld part than in the other parts. However, the cage pocket clearance of the pocket near the

gate part and near the weld part set up beforehand are larger than the other cage pocket clearances. Further, in paragraph [0009], the cage pocket clearances d and d1 are the differences between a pocket radius and a rolling-element radius.

In summary, there are differences between "the size for the opening of a pocket" of claim 8 and "the cage pocket clearance" of Otsutake because they can be changed or selected independently and have different functions and objects. Claim 8 has the size for the opening of a pocket to prevent the occurrence of crack or breakage at the bottom of the pocket that has the weld line and drop off of the cage. In contrast, "the cage pocket clearance" of Otsutake has retained the cage pocket clearance between a rolling element and the internal circumference of the pocket having the weld line and drop off of the cage.

If one with ordinary skill in the art wishes to retain largely the cage pocket clearance at the pocket having the weld line, it can not be accomplished by changing the size for the opening of a pocket. In addition, if one with ordinary skill in the art wishes to prevent the occurrence of crack or breakage at the bottom of the pocket having the weld line and drop off of the cage, it can not be accomplished by way of changing the cage pocket clearance at the pocket having the weld line, since the two parameters do not have a reciprocal relationship and have different functions and objects.

Therefore, Otsutake does not teach or suggest the opening of a pocket and cannot render claim 8 obvious.

Rejection of claim 9 as unpatentable over Niizeki in view of Yasui and further in view of Masuda

Claim 9 has been amended, and the amendment is supported by the specification as originally filed (see, for example, page 91, lines 14-24, and Figs. 15-17, especially Fig. 16). Therefore, no new matter has been added.

In amended claim 19, the intrusion of a lubricant agent is facilitated to improve the lubrication between the cage and the rolling elements. In other words, fluoro-lubricants can easily intrude between the cage and the rolling element by circulating from a through hole to the chamfering portion or vice versa at the bottom of the pocket.

By contrast, the chamfer of Yasui is formed on the side end face of a pocket opening. Therefore, the weight of the opening is reduced by the chamfer, and the cage can reduce the pocket opening deformation caused by a centrifugal force. However, this chamfer does not facilitate lubricant circulation from a through hole to the chamfering portion or vice versa, because the chamfer is formed on the side end face of an pocket opening in order to reduce the pocket opening deformation by a centrifugal force.

Therefore, it is difficult for the chamfer of Yasui to improve the lubrication between the cage and the rolling element. Consequently, the rejection of claim 9 as unpatentable over Niizeki in view of Yasui and further in view of Masuda has been overcome by the amendment to claim 9.

In light of the foregoing remarks, this application is considered to be in condition for allowance, and early passage of this case to issue is respectfully requested. If there are any questions regarding this amendment or the application in general, a telephone call to the undersigned would be appreciated since this should expedite the prosecution of the application for all concerned.

If necessary to effect a timely response, this paper should be considered as a petition for an Extension of Time sufficient to effect a timely response, and please charge any deficiency in fees or credit any overpayments to Deposit Account No. 05-1323 (CAM #: 038921.49472US).

Respectfully submitted,

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